U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-256 609

Hamilton Lake
Steuben County, Indiana

Pacific Northwest Environmental Res. Lab.

Prepared For
National Environmental Research Center

April 1976

243050

PB 256 609

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON
and
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

TECHNICAL REPORT DATA
(Please read Instructions on the Reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE
Report on Hamilton Lake, Steuben County, Indiana

5. REPORT DATE
Prepared April, 1976

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Anonymous (National Eutrophication Survey Staff)

8. PERFORMING ORGANIZATION REPORT NO.
Working Paper # 328

9. PERFORMING ORGANIZATION NAME AND ADDRESS
National Eutrophication Survey
U.S. Environmental Protection Agency
200 S. W. 35th St.
Corvallis, Oregon 97330

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.

12. SPONSORING AGENCY NAME AND ADDRESS
Office of Research and Development
U.S. Environmental Protection Agency
401 M Street, S. W.
Washington, DC 20460

13. TYPE OF REPORT AND PERIOD COVERED
Final - 1973

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release unlimited		38 pp.
	20. SECURITY CLASS *(This page)*	22. PRICE
		4.00

EPA Form 2220-1 (9-73)

PRICES SUBJECT TO CHANGE

REPORT
ON
HAMILTON LAKE
STEUBEN COUNTY
INDIANA
EPA REGION V
WORKING PAPER No. 328

WITH THE COOPERATION OF THE
INDIANA STATE BOARD OF HEALTH
AND THE
INDIANA NATIONAL GUARD
APRIL, 1976

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning {§303(e)}, water quality criteria/standards review {§303(c)}, clean lakes {§314(a,b)}, and water quality monitoring {§106 and §305(b)} activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

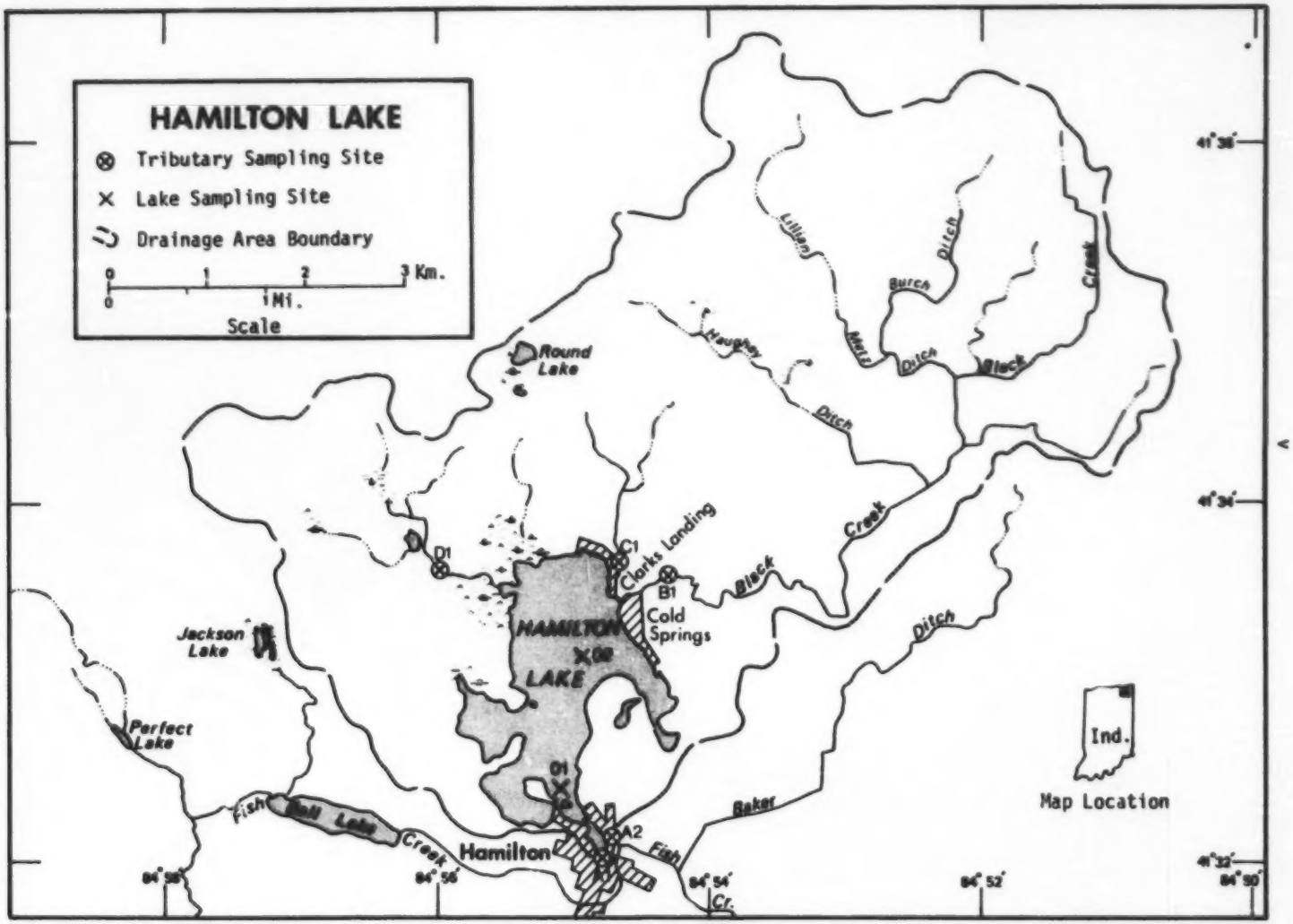
Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange


HAMILTON LAKE
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
0 1 2 3 Km.
0 1 Mi.
Scale
Round Lake
Lillian
Burch Ditch
Creek
Haughey
Metz Ditch
Black
Ditch
Clarks Landing
C1
D1
B1
Cold Springs
Black Creek
HAMILTON LAKE
Jackson Lake
Perfect Lake
Ditch
Ind.
Map Location
D2
Fish
Hall Lake
Creek
Hamilton
A2
Baker
Fish
Cr.
41°36'
41°34'
41°32'
84°58'
84°56'
84°54'
84°52'
84°50'

HAMILTON LAKE

STORET NO. 1857

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Hamilton Lake is eutrophic. It ranked fourteenth in overall trophic quality when the 27 Indiana lakes sampled in 1974 were compared using a combination of six parameters*. Eleven of the lakes had less median total phosphorus, 21 had less median dissolved phosphorus, nine had less median inorganic nitrogen, 18 had less mean chlorophyll a, and seven had greater mean Secchi disc transparency. Hypolimnetic dissolved oxygen was depleted at both sampling stations in August and October.

Survey limnologists noted a moderate algal bloom and many submerged and emergent macrophytes in August.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Hamilton Lake was phosphorus limited at the time the sample was collected (05/03/73). The lake data indicate phosphorus limitation in May as well but nitrogen limitation in August and October.

C. Nutrient Controllability:

1. Point sources--The estimated phosphorus contribution from septic tanks serving lakeshore dwellings amounted to 5.3% of the total reaching Hamilton Lake during the sampling year, but a shore-

* See Appendix A.

line survey would be needed to determine the significance of those sources.

The present phosphorus loading of 0.32 $g/m^2/yr$ is a little less than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11). Providing the septic tank phosphorus load has not been underestimated, and the overall loading is not increased, the trophic condition of the lake should improve gradually. It may take some time for the improvement to become readily apparent, however, since the mean hydraulic retention time of the lake is 1.8 years, and the loading is only 0.04 $g/m^2/yr$ less than a eutrophic loading.

The trophic condition of Hamilton Lake in 1973 probably was the result of higher phosphorus loadings prior to the Indiana phosphate detergent ban of January, 1972, which resulted in an estimated 50% decrease in domestic wastewater phosphorus.

2. Non-point sources--Almost 95% of the total phosphorus input to Hamilton Lake came from non-point sources during the sampling year. Contributing sources included Black Creek (59.8%), Unnamed Stream C-1 (6.3%), and Unnamed Stream D-1 (5.3%). The ungaged tributaries and immediate drainage were estimated to have contributed 18.0% of the total load.

The phosphorus export rates of the tributaries were similar to the rates of other tributaries sampled in Steuben County; e.g., the rates of the two tributaries of nearby Pigeon Lake* were 23 and 31 $kg/km^2/yr$.

* Working Paper No. 340.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 3.25 kilometers^2.
2. Mean depth: 6.3 meters.
3. Maximum depth: 21.3 meters.
4. Volume: 20.475 x 10^6 m^3.
5. Mean hydraulic retention time: 1.8 years.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Black Creek	24.1	0.22
Unnamed Creek C-1	3.1	0.03
Unnamed Creek D-1	3.6	0.03
Minor tributaries & immediate drainage -	8.8	0.08
Totals	39.6	0.36

2. Outlet -

Fish Creek	21.4	0.18
North Outlet	21.4	0.18
Total	42.8**	0.36**

C. Precipitation***:

1. Year of sampling: 111.6 centimeters.
2. Mean annual: 91.3 centimeters.

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† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Hamilton Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 10.1 meters at station 1 and 19.8 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR HAMILTON LAKE
STORET CODE 1857

PARAMETER	1ST SAMPLING (5/ 3/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 4/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/13/73) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	8.9 - 13.2	12.8	12.6	10.4 - 24.7	18.8	16.7	9.3 - 18.6	15.2	16.1
DISS OXY (MG/L)	1.8 - 9.6	7.8	8.7	0.8 - 8.2	2.7	0.3	0.8 - 8.0	2.8	0.9
CNDCTVY (MCROMO)	420. - 435.	429.	430.	312. - 360.	335.	341.	313. - 366.	327.	319.
PH (STAND UNITS)	7.8 - 8.2	8.1	8.2	7.1 - 8.6	7.6	7.3	7.0 - 8.4	7.7	7.6
TOT ALK (MG/L)	153. - 171.	159.	159.	128. - 187.	151.	156.	134. - 230.	160.	151.
TOT P (MG/L)	0.021 - 0.887	0.031	0.025	0.027 - 0.476	0.128	0.039	0.020 - 0.804	0.170	0.044
ORTHO P (MG/L)	0.002 - 0.057	0.017	0.011	0.007 - 0.382	0.088	0.024	0.016 - 0.552	0.121	0.027
NO2+NO3 (MG/L)	0.340 - 0.600	0.569	0.600	0.060 - 0.750	0.238	0.130	0.030 - 0.090	0.046	0.035
AMMONIA (MG/L)	0.020 - 0.650	0.187	0.130	0.060 - 2.440	0.585	0.100	0.060 - 5.490	1.214	0.355
KJEL N (MG/L)	0.680 - 1.480	0.783	0.650	0.700 - 3.500	1.508	1.300	0.700 - 7.000	2.188	1.100
INORG N (MG/L)	0.620 - 0.990	0.756	0.720	0.130 - 2.560	0.823	0.770	0.090 - 5.570	1.260	0.305
TOTAL N (MG/L)	1.180 - 1.880	1.352	1.245	0.960 - 3.620	1.747	1.465	0.740 - 7.080	2.154	1.135
CHLRPYL A (UG/L)	2.5 - 2.6	2.5	2.5	8.5 - 80.9	44.7	44.7	5.0 - 5.2	5.1	5.1
SECCHI (METERS)	2.1 - 3.7	2.9	2.9	1.3 - 1.4	1.4	1.4	2.3 - 2.4	2.4	2.4

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/03/73	1. Aphanizomenon sp.	195
	2. Melosira sp.	114
	3. Flagellates	114
	4. Coccoid cells	81
	5. Asterionella sp.	32
	Other genera	48
	Total	584
08/04/73	1. Oscillatoria sp.	1,187
	2. Coccoid cells	890
	3. Merismopedia sp.	244
	4. Microcystis sp.	244
	5. Fragilaria sp.	192
	Other genera	612
	Total	3,369
10/13/73	1. Lyngbya sp.	244
	2. Fragilaria sp.	198
	3. Microcystis sp.	137
	4. Aphanizomenon sp.	107
	5. Chroococcus sp.	91
	Other genera	305
	Total	1,082

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/03/73	1	2.6
	2	2.5
08/04/73	1	80.9
	2	8.5
10/13/73	1	5.0
	2	5.2

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.010	0.776	0.8
0.050 P	0.060	0.776	18.0
0.050 P + 1.0 N	0.060	1.776	19.7
1.0 N	0.010	1.776	1.4

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Hamilton Lake was moderate at the time the sample was collected. There was a significant increase in yield when only orthophosphorus was added, but there was no significant change when only nitrogen was added. Based on these results, phosphorus limitation is indicated.

The lake data indicate nitrogen limitation in August and in October; the mean inorganic nitrogen/orthophosphorus ratios were 9/1 and 10/1, respectively, and nitrogen limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in $kg/km^2/year$, at stations B-1, C-1, and D-1 and multiplying the means by the ZZ area in km^2.

All estimated point-source phosphorus loads were reduced by 50% to adjust for a phosphate detergent ban in effect in Indiana since 1972.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

* See Working Paper No. 175.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Black Creek	615	59.8
Unnamed Creek C-1	65	6.3
Unnamed Creek D-1	55	5.3
b. Minor tributaries & immediate drainage (non-point load) -	185	18.0
c. Known municipal STP's - None	-	-
d. Septic tanks* -	55	5.3
e. Known industrial - None	-	-
f. Direct precipitation** -	55	5.3
Total	1,030	100.0

2. Outputs -

Lake outlets -	Fish Creek	225
	North Outlet	315
	Total	540

3. Net annual P accumulation - 490 kg.

* Estimate based on 371 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Black Creek	22,200	56.8
Unnamed Creek C-1	1,705	4.4
Unnamed Creek D-1	1,860	4.8
b. Minor tributaries & immediate drainage (non-point load) -	5,830	14.9
c. Known municipal STP's - None	-	-
d. Septic tanks* -	3,955	10.1
e. Known industrial - None	-	-
f. Direct precipitation** -	3,510	9.0
Total	39,060	100.0

2. Outputs -

Lake outlets - Fish Creek	9,890	
North Outlet	8,565	
Total	18,455	

3. Net annual N accumulation - 20,605 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Black Creek	26	921
Unnamed Creek C-1	21	550
Unnamed Creek D-1	15	517

* Estimate based on 371 lakeshore dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.32	0.15	12.0	6.3

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Hamilton Lake:

"Dangerous" (eutrophic loading)	0.36
"Permissible" (oligotrophic loading)	0.18

V. LITERATURE REVIEWED

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Winters, John, 1975. Personal communication (lake morphometry). IN Stream Poll. Contr. Agency, Indianapolis.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1805	CATAWACT LAKE	0.056	1.660	466.667	10.744	15.000	0.013
1811	GEIST RESERVOIR	0.074	1.080	472.500	45.950	11.600	0.009
1817	JAMES LAKE	0.024	1.030	434.000	11.533	15.000	0.006
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.778	15.000	0.029
1828	MONROE RESERVOIR	0.025	0.325	438.823	6.947	15.000	0.007
1829	MORSE RESERVOIR	0.084	3.325	473.222	56.167	15.000	0.009
1836	WAWASEE LAKE	0.012	0.210	364.500	5.800	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.084	1.620	470.167	33.083	15.000	0.012
1840	WINONA LAKE	0.035	1.250	444.667	11.211	15.000	0.011
1841	WESTLER LAKE	0.035	0.060	427.125	10.712	15.000	0.013
1842	WITHER LAKE	0.035	0.980	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	408.480	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.019	0.195	391.500	6.050	15.000	0.005
1845	DALLAS LAKE	0.029	0.830	413.333	10.067	15.000	0.010
1846	OLIN LAKE	0.012	1.460	403.333	4.867	14.900	0.003
1847	OLIVER LAKE	0.009	0.920	392.000	3.767	14.000	0.004
1848	SYLVAN LAKE	0.170	0.130	469.833	47.480	14.800	0.017
1849	HOVEY LAKE	0.062	1.050	489.333	84.267	7.600	0.024
1850	VERSAILLES LAKE	0.139	1.090	482.000	25.070	14.500	0.019
1851	BASS LAKE	0.040	0.250	471.375	29.367	7.000	0.012
.852	CROOKED LAKE	0.019	0.120	410.111	5.578	15.000	0.005
1853	LAKE JAMES	0.016	0.190	352.444	4.856	15.000	0.005
1854	LONG LAKE	0.204	1.920	442.667	16.100	15.000	0.150
1855	PIGEON LAKE	0.058	1.945	442.667	11.900	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.055
1857	HAMILTON LAKE	0.033	0.720	413.167	17.450	15.000	0.018

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INVER NU
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MORSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	85 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	42 (11)	157
1840	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLER LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WITMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	279
1843	LAKE MAXINKUCKEE	77 (20)	81 (21)	85 (22)	85 (22)	35 (0)	98 (25)	461
1844	TIPPECANOE LAKE	85 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (21)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	94 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	HOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	449
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	486
1854	LONG LAKE	8 (8)	12 (3)	44 (11)	35 (9)	35 (0)	8 (8)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	HANSN LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1836	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROOKED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	281
15	1842	WITHER LAKE	279
16	1840	WINONA LAKE	260
17	1811	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1805	CATAHACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1857 HAMILTON LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 42.7

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1857A1	21.4	0.249	0.306	0.439	0.408	0.261	0.201	0.119	0.040	0.037	0.040	0.105	0.190	0.199
1857A2	21.4	0.249	0.306	0.439	0.408	0.261	0.201	0.119	0.040	0.037	0.040	0.105	0.190	0.199
1857B1	24.1	0.280	0.343	0.496	0.459	0.294	0.227	0.136	0.042	0.042	0.045	0.119	0.221	0.225
1857C1	3.1	0.034	0.042	0.065	0.059	0.037	0.028	0.017	0.004	0.005	0.005	0.015	0.028	0.028
1857D1	3.6	0.040	0.051	0.076	0.071	0.042	0.034	0.020	0.005	0.006	0.006	0.018	0.034	0.033
1857Z2	8.8	0.099	0.125	0.184	0.170	0.108	0.082	0.048	0.014	0.014	0.015	0.042	0.082	0.082

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 42.7
SUM OF SUB-DRAINAGE AREAS = 82.4

TOTAL FLOW IN = 9.23
TOTAL FLOW OUT = 0.0

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1857A1	6	73	0.151	10	0.283				
	7	73	0.155	15	0.161				
	8	73	0.046	12	0.127				
	9	73	0.018	16	0.034				
	10	73	0.051	10	0.051				
	11	73	0.083	10	0.037				
	12	73	0.166	8	0.136				
	1	74	0.467	6	0.142				
	2	74	0.314	10	0.161	24	0.821		
	3	74	0.413	12	0.651	26	0.181		
	4	74	0.212	15	0.229				
	5	74	0.232	5	0.127				
1857A2	6	73	0.082	10	0.481				
	7	73	0.191	15	0.263				
	8	73	0.017	12	0.051				
	9	73	0.007	16	0.012				
	10	73	0.019	10	0.010				
	11	73	0.031	10	0.0				
	12	73	0.270	8	0.051				
	1	74	0.765	6	0.142				
	2	74	0.515	10	0.249	24	1.359		
	3	74	0.671	12	1.048	26	0.284		
	4	74	0.345	15	0.368				
	5	74	0.382	5	0.071				

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1857 HAMILTON LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1857B1	6	73	0.131	10	0.195				
	7	73	0.195	15	0.102				
	8	73	0.036	12	0.048				
	9	73	0.014	16	0.0				
	10	73	0.039	10	0.0				
	11	73	0.064	10	0.0				
	12	73	0.246	8	0.048				
	1	74	0.494	6	0.065				
	2	74	0.467	10	0.096	24	0.651		
	3	74	0.612	12	0.481	26	0.091		
	4	74	0.314	15	0.147				
	5	74	0.345	5	0.034				
1857C1	6	73	0.017	10	0.031				
	7	73	0.025	15	0.016				
	8	73	0.005	12	0.006				
	9	73	0.002	16	0.001				
	10	73	0.005	10	0.002				
	11	73	0.008	10	0.001				
	12	73	0.032	8	0.007				
	1	74	0.089	6	0.010				
	2	74	0.060	10	0.015	24	0.096		
	3	74	0.079	12	0.074	26	0.014		
	4	74	0.040	15	0.023				
	5	74	0.045	5	0.007				
185701	6	73	0.020	10	0.054				
	7	73	0.029	15	0.034				
	8	73	0.005	12	0.015				
	9	73	0.002	16	0.004				
	10	73	0.006	10	0.006				
	11	73	0.010	10	0.004				
	12	73	0.037	8	0.016				
	1	74	0.104	6	0.023				
	2	74	0.070	10	0.031	24	0.147		
	3	74	0.092	12	0.116	26	0.031		
	4	74	0.047	15	0.045				
	5	74	0.052	5	0.016				
1857Z2	6	73	0.048	10	0.156				
	7	73	0.071	15	0.037				
	8	73	0.013	12	0.014				
	9	73	0.005	16	0.0				
	10	73	0.014	10	0.0				
	11	73	0.024	10	0.0				
	12	73	0.090	8	0.014				
	1	74	0.254	6	0.024				
	2	74	0.171	10	0.034	24	0.238		
	3	74	0.224	12	0.176	26	0.034		
	4	74	0.115	15	0.054				
	5	74	0.126	5	0.012				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

185701
41 32 25.0 084 55 06.0 3
HAMILTON LAKE
18151 INDIANA
060102

11EPALES 2111202
0034 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT K JEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/03	09 45	0000	12.6		84	425	8.20	162	0.140	1.200	0.600	0.013
	09 45	0006	12.6	9.3		425	8.20	163	0.120	0.600	0.680	0.010
	09 45	0015	12.4	8.8		435	8.20	163	0.130	0.700	0.590	0.011
	09 45	0022	12.1	8.7		420	8.20	163	0.140	0.600	0.580	0.010
	09 45	0030	8.9	1.8		435	7.90	171	0.650	1.400	0.340	0.057
73/08/04	09 30	0000	24.7	7.4	51	344	8.40	128	0.110	1.400	0.000	0.007
	09 30	0005	24.3			348						
	09 30	0010	24.2	5.0		350	7.90	131	0.070	0.900	0.060	0.025
	09 30	0015	21.0	0.3		360	7.20	157	0.640	1.400	0.090	0.024
	09 30	0020	15.1	0.0		339	7.10	163	0.090	1.000	0.140	0.041
	09 30	0025	13.0			332						
	09 30	0030	11.8	0.0		336	7.10	179	2.440	3.500	0.120	0.310
73/10/13	09 25	0000	10.1	7.6	90	315	8.40	138	0.070	1.000	0.040	0.022
	09 25	0010	17.3	1.8		313	7.70	138	0.230	0.900	0.030	0.017
	09 25	0022	15.0	0.0		348	7.40	164	1.310	2.300	0.090	0.032
	09 25	0025	13.0	0.0		347	7.30	190	2.640	3.800	0.060	0.176
	09 25	0033	10.8	0.0		366	7.00	230	5.490	7.000	0.000	0.552

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/03	09 45	0000	0.025	2.6
	09 45	0006	0.021	
	09 45	0015	0.026	
	09 45	0022	0.026	
	09 45	0030	0.087	
73/08/04	09 30	0000	0.034	80.9
	09 30	0010	0.037	
	09 30	0015	0.054	
	09 30	0020	0.122	
	09 30	0030	0.475	
73/10/13	09 25	0000	0.039	5.0
	09 25	0010	0.026	
	09 25	0022	0.088	
	09 25	0025	0.196	
	09 25	0033	0.636	

STORET RETRIEVAL DATE 76/03/30

185702
41 33 89.0 084 54 57.0 3
HAMILTON LAKE
18151 INDIANA
060192

11EPALES 2111202
0066 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 N02&N03 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/03	10 20	0000	13.2		144	438	8.10	156	0.130	0.800	0.600	0.008
	10 20	0006	13.2	9.4		438	8.20	155	0.120	0.600	0.600	0.009
	10 20	0015	13.2	9.5		435	7.80	155	0.020	0.600	0.600	0.002
	10 20	0025	13.2	9.6		425	8.20	154	0.120	0.600	0.600	0.011
	10 20	0035	13.1	6.2		438	8.20	153	0.120	0.600	0.600	0.012
	10 20	0048	9.8	7.8		438	8.10	153	0.230	0.800	0.500	0.021
	10 20	0062	9.3	6.5		438	8.00	165	0.320	0.900	0.540	0.034
73/08/04	10 10	0000	24.6	8.2	56	347	8.60	128	0.070	1.200	0.070	0.018
	10 10	0005	24.6			342						
	10 10	0010	24.4	7.4		348	8.50	130	0.060	1.000	0.070	0.010
	10 10	0015	23.6	3.6		348	7.40	134	0.090	0.900	0.160	0.015
	10 10	0020	18.4	0.2		342	7.30	156	0.060	0.700	0.750	0.019
	10 10	0025	14.8	0.3		322	7.30	156	0.070	0.700	0.750	0.030
	10 10	0030	13.5			318						
	10 10	0040	13.0			315						
	10 10	0050	12.1	0.2		312	7.30	165	0.440	1.400	0.430	0.153
	10 10	0060	10.9			315						
	10 10	0065	10.4	0.0		320	7.20	187	2.080	3.200	0.140	0.382
73/10/13	10 05	0000	18.6	8.0	96	319	8.40	134	0.110	0.900	0.030	0.018
	10 05	0010	18.5	8.0		319	8.40	135	0.060	0.800	0.030	0.016
	10 05	0020	18.3	6.2		318	8.10	138	0.100	0.800	0.030	0.017
	10 05	0025	17.2	2.6		318	7.70	144	0.160	0.700	0.040	0.016
	10 05	0030	14.0	0.0		325	7.50	157	0.480	1.200	0.030	0.032
	10 05	0040	11.0	0.0		315	7.50	161	0.500	1.200	0.030	0.064
	10 05	0065	9.3	0.0		324	7.20	196	3.340	4.700	0.060	0.492

STORET RETRIEVAL DATE 76/03/30

185702
41 33 09.0 084 54 57.0 3
HAMILTON LAKE
18151 INDIANA
060192

11EPALES 2111202
0066 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/03	10 20	0000	0.021	2.5
	10 20	0006	0.026	
	10 20	0015	0.023	
	10 20	0025	0.024	
	10 20	0035	0.023	
	10 20	0048	0.031	
	10 20	0062	0.045	
73/08/04	10 10	0000	0.029	8.5
	10 10	0010	0.029	
	10 10	0015	0.037	
	10 10	0020	0.027	
	10 10	0025	0.041	
	10 10	0050	0.170	
	10 10	0065	0.476	
73/10/13	10 05	0000	0.033	5.2
	10 05	0010	0.030	
	10 05	0020	0.020	
	10 05	0025	0.021	
	10 05	0030	0.049	
	10 05	0040	0.094	
	10 05	0065	0.804	

APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/03/30

1857A1
41 32 02.0 084 54 16.0 4
FISH CREEK
18 7.5 HAMILTON
O/HAMILTON LAKE 060192
HWY 427 BRDG BY USGS GAGE IN HAMILTON
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/10	09 25		0.280	0.970	0.063	0.009	0.035
73/07/15	10 50		0.048	1.500	0.061	0.006	0.035
73/08/12	12 00		0.010K	1.050	0.025	0.009	0.045
73/09/16	09 20		0.010K	1.050	0.030	0.008	0.045
73/10/10	17 15		0.019	0.970	0.040	0.021	0.055
73/11/10	10 35		0.028	0.550	0.036	0.012	0.025
73/12/08	10 45		0.084	0.800	0.044	0.008	0.020
74/01/06	11 40		0.264	0.700	0.064	0.006	0.015
74/02/10	09 50		1.120	1.300	0.060	0.020	0.050
74/02/24	10 24		1.400	1.900	0.020	0.010	0.040
74/03/12	17 05		0.820	0.700	0.020	0.010	0.030
74/03/26	18 20		0.480	0.900	0.025	0.005	0.040
74/04/15	18 40		0.610	0.800	0.045	0.005	0.020
74/05/05	14 15		0.252	0.800	0.170	0.020	0.045

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

1857A2
41 32 10.0 084 54 16.0 4
NORTH OUTLET
18 7.5 HAMILTON
T/HAMILTON LAKE 060192
CRYSTAL LK RD BRDG IN HAMILTON
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/10	09 35		0.336	1.050	0.063	0.032	0.035
73/07/15	10 45		0.046	1.100	0.063	0.006	0.040
73/08/12	12 10		0.010K	0.960	0.048	0.009	0.045
73/09/16	09 30		4.300	4.300	0.033	0.990	1.650
73/10/10	17 50		0.068	1.890	0.066	0.037	0.210
73/12/08	11 00		0.076	0.500	0.036	0.008	0.015
74/01/06	11 55		0.312	0.700	0.060	0.005K	0.015
74/02/10	10 10		1.700	0.900	0.040	0.025	0.070
74/02/24	10 26		0.196	0.500	0.020	0.005K	0.040
74/03/12	17 10		0.820	0.800	0.010	0.010	0.035
74/03/26	18 10		0.630	0.800	0.020	0.005	0.035
74/04/15	18 30		0.640	0.600	0.025	0.005K	0.020
74/05/05	14 05		0.232	0.800	0.015	0.005	0.035

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

185781
41 33 40.0 084 54 16.0 4
BLACK CREEK
18 7.5 HAMILTON
I/HAMILTON LAKE 060192
HWY 1 BRDG .4 E OF CLARKS LANDING
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/10	09	00	1.560	2.400	0.080	0.100	0.145
73/07/15	10	25	1.120	2.200	0.046	0.065	0.160
73/08/12	12	15	1.600	1.900	0.039	0.042	0.250
73/12/08	11	15	2.520	1.250	0.036	0.020	0.035
74/01/06	12	10	3.000	0.900	0.032	0.016	0.030
74/02/10	10	10	2.200	1.500	0.040	0.020	0.050
74/02/24	10	03	1.920	0.800	0.025	0.015	0.050
74/03/12	17	30	2.300	1.300	0.020	0.030	0.135
74/03/26	18	00	1.600	0.600	0.015	0.010	0.035
74/04/15	18	20	1.600	0.900	0.025	0.017	0.030
74/05/05	13	55	0.232	0.800	0.015	0.005K	0.032

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

1857C1
41 33 40.0 084 54 44.0 4
UNNAMED CREEK
18 7.5 HAMILTON
T/HAMILTON LAKE 060192
SEC RD BRDG AT CLARKS LANDING
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/10	08 55		0.240	1.200	0.084	0.006	0.060
73/07/15	10 35		0.273	1.150	0.056	0.015	0.130
73/08/12	12 20		0.200	0.760	0.026	0.005K	0.055
73/09/16	09 45		0.485	0.600	0.031	0.014	0.050
73/10/10	18 10		0.105	0.730	0.028	0.014	0.052
73/11/10	11 15		0.264	0.400	0.032	0.008	0.015
73/12/08	11 30		0.168	0.800	0.020	0.008	0.030
74/01/06	12 15		0.850	1.400	0.020	0.012	0.115
74/02/10	10 15		1.600	1.700	0.080	0.010	0.115
74/02/24	10 46		1.760	1.400	0.105	0.020	0.280
74/03/12	17 15		1.430	1.100	0.070	0.005	0.050
74/03/26	17 50		1.120	1.400	0.050	0.005	0.030
74/04/15	18 10		0.930	0.600	0.025	0.005	0.020
74/05/05	13 45		0.240	0.900	0.015	0.005K	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

185701
41 33 43.0 084 55 59.0 4
UNNAMED CREEK
18 7.5 HAMILTON
T/HAMILTON LAKE 060192
SEC RD BRDG .4 MI NW OF LAKE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/10	09 50		0.220	1.380	0.082	0.015	0.045
73/07/15	11 15		0.140	1.680	0.078	0.019	0.055
73/08/12	11 45		0.200	0.800	0.048	0.012	0.055
73/09/16	09 10		0.080	0.820	0.095	0.010	0.037
73/10/10	17 20		0.084	0.620	0.060	0.013	0.040
73/11/10	11 00		0.112	0.200	0.052	0.008	0.025
73/12/08	10 15		0.410	0.400	0.064	0.008	0.020
74/01/06	13 25		0.792	0.800	0.040	0.008	0.055
74/02/10	09 40		1.200	1.000	0.060	0.005	0.022
74/02/24	10 50		3.100	1.900	0.075	0.050	0.240
74/03/12	17 30		1.180	1.000	0.020	0.015	0.050
74/03/26	17 40		0.850	0.600	0.015	0.005	0.020
74/04/15	18 00		0.630	0.700	0.030	0.005K	0.010
74/05/05	13 30		0.240	0.800	0.030	0.010	0.055

K VALUE KNOWN TO BE
LESS THAN INDICATED